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5 The Trans-Alaska Pipeline System (TAPS): Planning, Design, and Construction (1968–1977)*

5.1 BACKGROUND

Early in 1968, the Atlantic-Richfield Company (ARCO), which had been engaged in exploratory drilling on Alaska's North Slope, announced that its well had encountered a substantial flow of gas at 8500 feet (2591 meters). Further exploratory drilling confirmed that significant amounts of oil and gas were indeed present, and in a few months it became clear that reserves in the area represented the largest oil field ever discovered in the U.S. The site of the discovery, the Prudhoe Bay region on Alaska's Arctic Ocean coastline, is a remote area then accessible year round only by air and only briefly during the summer by ships. The magnitude of the field clearly made it a priority for development to the production stage, but, just as clearly, a major transportation system would have to be constructed before any oil could be sent to market.

The system ultimately chosen was a pipeline: an 800-mile (1287 kilometers) link from the arctic coast to the ice-free port of Valdez on the Gulf of Alaska. In Valdez, oil would be shipped by tankers to refineries or other pipelines on the U.S. west coast. In summary, the project would consist of three major components: the pipeline, which would cross three mountain ranges, the pump stations, and the marine terminal. The massiveness of the project was further complicated by both state and federal relationships and the Alaska construction cycle.

In Alaska, the federal influence has always been disproportionately great. Before statehood, all significant legal power in Alaska was held by the federal government. Federal employment, both military and civil, was a major source of income. When Alaska attained statehood in January 1959, the legal power

* Adapted from *The Trans-Alaska Pipeline*, a case history by George Geistauts and Vern Hauck (edited by L.J. Goodman and R.N. Love), Honolulu: East-West Center, Resource Systems Institute, 1979.

of Alaskans to control their state and their lives expanded substantially. However, the federal government still remained a major influence in Alaska, not only because it had increased its power throughout the U.S., but to a great extent because it retained title to almost all of the land in Alaska.

For the proposed pipeline, these power relationships had two implications: (1) the federal government would exert a major influence in authorizing pipeline construction and in establishing rules governing design, construction practices, and hiring; and (2) the state government would also exert authority and control over the project. Further, to the extent that state and federal interests differed, those building the pipeline would face contradictory pressures and demands. At the very least, duplication could be expected in the areas of project oversight controls and reporting requirements. Conflicts between these dual sources of authority could add to delays in construction and thus could increase management difficulties and ultimately raise costs.

In October 1968, ARCO, Humble, and British Petroleum (BP) formed the Trans-Alaska Pipeline System (TAPS) as an unincorporated joint venture. Since this organization was funded by and borrowed people from the sponsoring parent companies, the parent companies exerted control through a series of meetings and a number of committees. At this point, TAPS was more of an alliance than a tightly knit organization.

In November 1968, ARCO and Humble applied for land in Valdez for a terminal. By December, the feasibility studies were finished and the basic TAPS design concept had emerged. On February 10, 1969, ARCO, Humble, and BP formally announced their Alaska pipeline plan. Unlike some aspects of the detailed route and terminal location, which were still under study, the concept of a 48-inch (122 centimeters) diameter hot-oil pipeline approximately 800 miles long (1287 kilometers) clearly had been adopted. Initial capacity would be 500,000 barrels per day, rising to 1.2 million barrels by 1975, and finally to 2 million barrels by 1980. These increases in capacity would be made possible by adding more pump stations. Completion of the 500,000-barrel phase was expected by 1972 when the formal application for pipeline right-of-way and permission to build the necessary haul roads was submitted to the Bureau of Land Management (Alaska) in June 1969.

The Secretary of the Interior, Walter Hickel, outlined conditions for granting permits that indicated a long delay. Matters were further complicated by congressional passage of the National Environment Protection Act (NEPA) in December 1969 (approved January 1970). Indeed, the project was delayed four years because of environmental opposition, debate, legal actions, and Congressional action.

During the period of opposition and debate, TAPS had relatively little control of events and was essentially forced into a position of reacting. The original design plan had to be modified from one in which about 95 percent of the pipeline would be buried to one in which over one half (420 miles) would be above ground supported by expensive piling. Increasingly tighter stipulations proposed by the Interior Department further restricted Alyeska's* freedom of choice in design and construction practices.

5.2 THE ENVIRONMENT

The Trans-Alaska Pipeline System (TAPS) traverses the flat North Slope to enter the Brooks Range, where it climbs 4739 feet from sea level to crest Atigun Pass. It then descends to cross the wide Yukon River near Fairbanks, 450 miles from Prudhoe Bay. For the final 350 miles, TAPS passes through the Alaska Range at 3430 feet, descending and climbing again to top Thompson Pass at 2812 feet. It then drops down to Keystone Canyon and the terminal at Valdez. The pipeline route showing physical environment and wildlife is drawn in [Figure 5.1](#).

5.2.1 PHYSICAL ENVIRONMENT

The State of Alaska includes 586,000 square miles (1,517,740 km²), or over 375 million acres of land and inland water areas. Located in a semipolar region, 83 percent of it lying north of the 60th parallel and 27 percent north of the Arctic Circle, Alaska is far removed from the U.S. mainland.

Geographical features such as mountain ranges divide Alaska into several major regions, each with distinct geographic, climatological, and ecological features.

The region north of the Brooks Range (the North Slope) has a temperature range from 90°F to less than -60°F (32 to -51°C), with a mean annual temperature of 10 to 20°F (-12 to -7°C). Because of its very low precipitation, this area is referred to as an "arctic desert," even though the presence of permafrost (a condition in which, because of the short summer season, only the surface ground melts; underneath, the ground remains permanently frozen) prevents water from being absorbed into the ground and creates an ideal nesting area for waterfowl. The interior area south of the Brooks Range and north of the Alaska Range (which includes Mount McKinley, at 20,320 feet [6195 meters] the highest point in North America) has greater temper-

* Alyeska was the name given to the pipeline corporation (consortium of oil companies) in 1970.

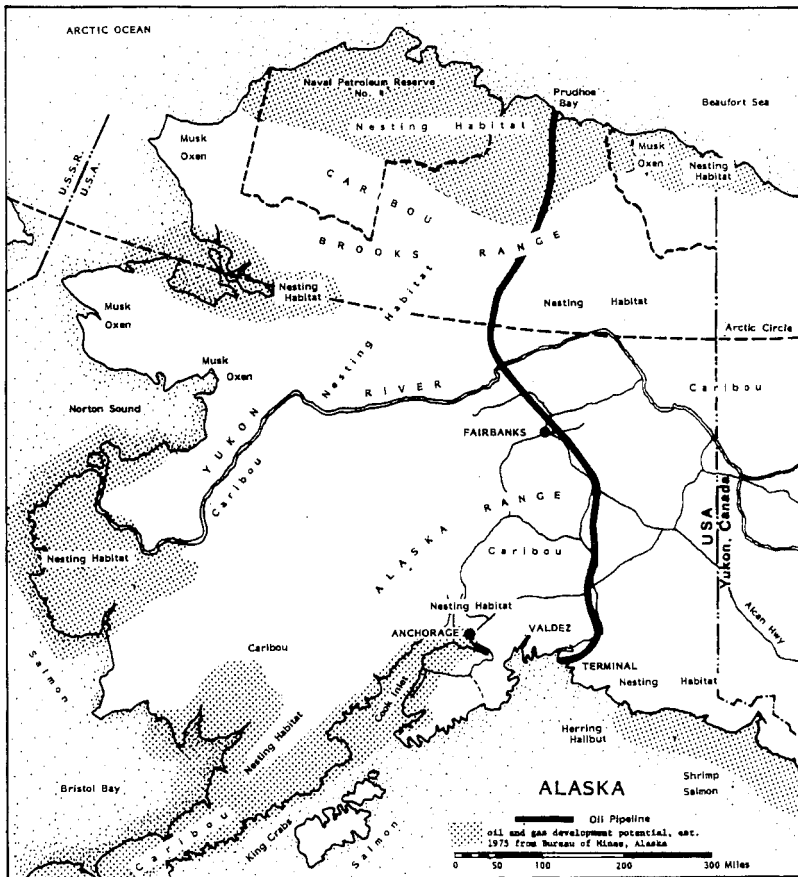


FIGURE 5.1 Pipeline route (showing the physical environment and wildlife of Alaska). (Compiled by East-West Resource Systems Institute staff.)

ature extremes, ranging from over 100°F to less than -70°F (38 to -57°C) and greater precipitation. The massive Yukon River winds its way through this region from its origins in Canada to the Bering Sea. This area includes Fairbanks, the state's second largest city.

The area south of the Alaska Range represents a transition to a maritime climate along the Gulf of Alaska's shoreline. Precipitation in this region is much higher and temperature changes are more moderate. All terminal sites that received serious consideration from TAPS were located in this maritime climate. Anchorage, the state's largest city, is located in this transition zone.

The state contains the 16 tallest mountains in the U.S., more than 120 million acres of lakes, approximately 11 million acres of glaciers, and 10,000

streams and rivers. From 50 to 90 rivers are considered by different sources to have recreational and wilderness values of national interest. Alaska has over 47,000 miles (75,639 kilometers) of tidal ocean shoreline.

Attracted by the scenery, camping, fishing, and hunting, visitors to Alaska enjoy the opportunity to experience the wilderness. The value of these resources cannot be measured solely in terms of revenue from this major industry in Alaska. The recreational opportunities and the wilderness experience are also very important to Alaskans themselves, since many moved to the state because of its wilderness character.

Alaska contains a number of minerals of national interest, including antimony, asbestos, chromium, copper, gold, iron, lead, and silver. Gold mining, an Alaska tradition, was responsible for the state's prosperity at the turn of the century, but gold now is produced on a relatively small scale. Alaska's energy-related resources include coal, uranium, a large number of hydroelectric sites, and significant geothermal potential. The most commercially exploitable resources are oil and gas. The TAPS could ultimately be expected to serve not only the Prudhoe Bay field but other northern fields as well, including offshore fields in that region.

Timber is a major harvestable resource in southeast Alaska but has minor commercial significance elsewhere. Finally, Alaska has been estimated to have great agricultural potential, even though the infrastructure to exploit it is not present and agricultural activities are of minor importance.

5.2.2 WILDLIFE

Because Alaska is a vast storehouse of natural resources, the state became a focal point in the battle between a development-oriented industry and environmentalists. Of particular significance to environmentalists (as well as indigenous Alaskans, fishermen, and others who utilized them for profit or for recreation) are resources such as fish, birds, and marine as well as terrestrial mammals, and a number of rare or endangered species (see [Figure 5.1](#)). Both pipeline and tankers would pass close to or through the habitats of much of this wildlife. While the oil companies assured everyone that environmental damage would be minimal, many of those outside the industry remained skeptical.

Traditionally, the primary renewable resource in Alaska has been fish. The salmon fishery, for example, is the major source of employment for many coastal communities. Additional coastal fishing resources include halibut, king crab, and shrimp. Inland fisheries are primarily sport oriented, although a number of rural-area residents depend on inland fish stocks for subsistence. An oil spill accident along the coastline or a massive leak from

a pipeline in the interior, then, could endanger a substantial economic and recreational resource.

Alaska provides 70 million acres (28,329,000 hectares) of the breeding habitat for 20 percent of all North American waterfowl (see [Figure 5.1](#)), which are an important source of food to Alaskans and an important game for recreational hunters throughout the U.S.. Alaska's coastline provides a feeding and breeding habitat for 27 species of marine mammals, including whales, walrus, seals, sea lions, and sea otters.

Alaska also is the home of polar bears, caribou, moose, black and brown bears, sheep, musk oxen, and many small fur bearers. Polar bears (which were declining alarmingly just a few years ago, but which have since recovered under a hunting prohibition) are found along the northern and north-western Arctic coast. Caribou are found throughout most of the state, especially in the Arctic areas. It was felt that the caribou's migration pattern might be altered by the disruption caused by the pipeline construction or even by its mere presence. Such a disruption might mean a drastic reduction in herd size.

5.2.3 VALDEZ AND PRINCE WILLIAM SOUND

Prince William Sound is one of the most pristine and magnificent natural areas in the country. It is an area of great natural beauty, and its rich natural resources form the basis for major commercial fisheries for pink and chum salmon and Pacific herring. There are many smaller family-owned fisheries for halibut, sable fish, crab and shrimp. Thus, the sound is the major food source for the Alaskan Native villages on its shore.

Chugach National Forest in the sound and Kenai Fjords National Park are not far from Anchorage, making the area a favorite location for recreational users. The area is the habitat and/or nesting sites for many species of marine mammals and birds, both shore birds and waterfowl.

Thus, environmentalists began to express concern about the operations of the Valdez Marine Terminal and the oil tanker shipments as early as 1971–1972. Port Valdez is an ice-free terminal, and estimated oil tanker shipments were predicted to average at least 12 each week.

5.3 PHASE 1: PLANNING, APPRAISAL, AND DESIGN

5.3.1 IDENTIFICATION AND FORMULATION

This has been covered above in Section 5.1.

5.3.2 PRELIMINARY DESIGN: FEASIBILITY STUDIES

The preliminary route selection was based on a combination of soil borings, soil temperature readings, air temperature data, geological studies, and aerial photographic interpretations. A right-of-way 100 feet in width was recommended for construction purposes for both pipeline excavation and haul road construction.

A formal application was filed by TAPS with the Office of the State Director, Bureau of Land Management, Anchorage, on June 6, 1969, for the pipeline right-of-way.¹ The application included the need for 11 pumping station easements, each 1200 by 1600 feet. Air strips of approximately 200 by 5000 feet were requested for stations 3 and 4. The rationale for the preliminary design selection is best summarized in the following excerpt from the application:

One of the prime considerations in selecting the route applied for herein was an in-depth analysis of soil conditions to insure a pipeline location providing maximum physical stability, maximum burial of the pipeline, and minimum disturbance of the natural environment. Extensive field examination in conjunction with ground-proofed aerial photographic interpretation was used in plotting the pipeline and construction road right-of-way alignment.

There are numerous special studies in progress to determine the best method of handling the Ecological, Archaeological and Conservation problems that will be encountered during and after the construction of the pipeline and road. Results of these studies will establish procedures to be used to meet all requirements of minimum changes to the terrain.²

In summary, the TAPS proposal was for a 48-inch (122-centimeters) diameter hot-oil pipeline which would be buried for over 90 percent of its 800-mile (1287-kilometer) length. The initial capacity would be 500,000 barrels a day, rising in stages to 2 million barrels a day. Approximately 641 miles (1031 kilometers) of the line would be across federal lands, with completion expected some time in 1972. The application also requested a right-of-way and permit to build a haul road of slightly less than 400 miles (644 kilometers) to support construction.

At this time, a "land freeze" moratorium on the disposition of federal lands in Alaska pending resolution of indigenous Alaskans' claims was in effect, but the TAPS owners nevertheless hoped for quick approval. In their view, permits would be granted in July 1969, and construction would follow shortly thereafter. TAPS had already made a substantial financial commitment to the pipeline by ordering 500,000 tons of 48-inch (122-centimeter)

pipe for U.S. \$100 million from three Japanese companies earlier in the year. An additional U.S. \$30 million order had also been placed for several of the giant pumps required to move the oil. ARCO's commitment already included a decision to build a new refinery at Cherry Point, Washington, to handle North Slope crude oil. (In September 1969, ARCO placed an order with the Bethlehem Steel Company for three new 120,000 dead-weight ton tankers.)

Prior to approval of the pipeline system and route, a series of debates took place between supporters and opponents in 1968 and 1969. Those who supported the project included:

- The oil industry, which had a resource but no way to reach a market.
- The State of Alaska, particularly through its government, which would derive substantial economic benefits from royal revenues and severance taxes (the state, in effect, owns 25 percent of Prudhoe Bay oil).
- Local state businesses and governments, which would benefit from increased economic activity and an increased tax base.
- Economically and defense-oriented federal government agencies, for whom economic growth, reduced balance-of-payments deficits, and energy independence were of prime importance.

Those who opposed the design choice included:

- The environmentalists, who feared irreparable damage to the environment from both the TAPS project and subsequent development.
- Federal agencies charged with preserving environmental quality.
- Some members of Congress, who either supported environmentalists or who preferred to have the oil diverted to the interior U.S., primarily the midwest.
- The indigenous Alaskans, who did not want to have land they were in the process of claiming crossed by a pipeline prior to the establishment of their claims.

Essentially, five basic alternatives emerged, apart from not developing the oil field at all. The alternatives were:

- The TAPS proposal of a combined system of pipeline and tankers, which would deliver oil to the U.S. west coast.
- A longer tanker route directly from Prudhoe, around Point Barrow, to the west coast.

- A sea route of almost 5000 miles (8045 kilometers) from Prudhoe through the Northwest Passage to the northeast.
- A railroad through Canada to the midwest.
- A trans-Canada pipeline to the midwest.

The alternatives that received most attention were the one across the northern portion of Alaska to the Canadian border, and from there through Canada, to link up with existing pipelines leading into either the midwestern or western states (alternative 5), and the original TAPS proposal (alternative 1).

Additional environmental feasibility studies, debates, and delays resulted when the National Environmental Policy Act of 1969 (NEPA) was approved on January 1, 1970. NEPA declared a national policy of encouraging productive and enjoyable harmony between man and his environment by promoting efforts to prevent or eliminate damage to the environment, as well as stimulating the health and welfare of man. An Environmental Quality Council was created to analyze environmental trends, appraise programs, and recommend national policies promoting improvement in the quality of the environment. Section 102 of the act outlined the specific requirements that any proposed action, including the pipeline project, would have to meet in terms delineating the environmental impact and providing for public comment. The act imposed environmental impact statement (EIS) requirements on all agencies and departments, including the Department of the Interior. Part C of Section 102 specifically required identification of adverse environmental impacts, consideration of alternatives, and public distribution of these documents.

5.3.3 PIPELINE SYSTEM DESIGN

To ensure that TAPS did comply with the new standards of environmental integrity and to ensure that the project could cope with the arctic environment, technical solutions representing new pipeline technology had to be developed. The principal technical problems to be overcome were:

- Insulating the permafrost from the hot oil in order to keep the permafrost stable so that the pipeline would not settle or sink and rupture.
- Providing enough flexibility in the line to handle thermal expansion as the hot oil started to move.
- Providing a design to resist rupture in case of a severe earthquake.
- Providing rupture detection systems so that, in case of rupture, the line could be shut down before much oil spilled.

- Providing rupture control by means of oil containment provisions at the pump stations and the terminal.
- Reducing air emissions of hydrocarbons at the terminal to preserve ambient air quality.
- Preventing minor oil leaks or spills in the waters of Port Valdez and providing rapid cleanup capability if such spills occurred.
- Providing collision avoidance systems in Port Valdez, particularly in the approaches to Valdez Narrows, to prevent tanker collisions.
- Providing game crossing along the pipeline route without disrupting traditional game migration patterns.

The solutions to technical design problems included the following:

- Where the pipeline is buried in permafrost, the line is insulated and the permafrost is refrigerated by pumping cold brine through buried pipes.
- Expansion due to the passage of heated oil through aboveground pipe is compensated for by building the pipe in a zigzag configuration. This converts expansion into sideways movement.
- Where required, aboveground vertical support members (VSMs) are designed with thermal radiation devices to prevent heat transfer to the permafrost.
- All tanks where bulk oil is stored are surrounded by dikes to contain any spills in case of rupture.
- Ballast water is pumped to a settling and filtration system for purification before being discharged into the sea.
- A vapor recovery system at the terminal prevents oil vapors from escaping into the atmosphere.
- Computer-aided centralized control of the system is provided by a master control station in Valdez.
- Pressure deviations and flow variations are monitored to detect any ruptures or leaks in the line. Valve shutdown will contain most of the oil within the pipeline, and cleanup crews are on standby to deal with spills. The whole line can be shut down in 10 minutes. Check valves prevent reverse flow.
- The terminal facility is designed to withstand an earthquake registering 8.5 on the Richter scale. Storage tanks are surrounded by dikes.
- Stringent enforcement of the “rules of the road” by the Coast Guard in the Valdez Narrows and its approaches, utilizing control concepts analogous to air traffic control, is designed to minimize the possibility of grounding or collision.

In summary, TAPS called for construction of (1) a haul road, (2) the pipeline itself, (3) pumping stations, and (4) the Valdez terminal. However, was this the total system required to transport oil and gas to markets? Actually, only part of the problem was solved. The west coast could only absorb a limited amount of Alaskan crude oil for its own use, and the high sulfur content of Alaskan oil made it difficult to refine in the facilities existing in that region. But shipping oil east from the west coast would require connections to the pipeline systems in the interior of the U.S.

5.4 PHASE 2: SELECTION, APPROVAL, AND ACTIVATION

5.4.1 SELECTION

Evaluation of the alternatives and final selection did not take place as an orderly sequence of analysis and review under the supervision of any single agency or individual. The process that took place is best described as adversary rather than as analytic. Each group attempted to advance its views through a combination of purportedly objective studies designed to reinforce its arguments, public relations efforts, congressional lobbying, and legal test actions.

The actions of the Interior Department, which apparently favored the TAPS concept throughout the process, were designed to issue a permit as soon as possible, provided that the permit could be linked to a framework which would ensure a certain amount of protection for both the environment and the claims of indigenous Alaskans. The latter objective was met by passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971. The Interior Department's way of ensuring environmental protection was to link the permit to a set of contractual stipulations which would govern construction, and adherence to which would be enforced by an on-the-scene "authorized officer" representing the department. The department also started to study a 12-mile wide transportation corridor along the proposed route, which would allow for some flexibility in response to conditions encountered during actual construction.

Despite the favorable attitude of the Interior Department, officially authorized construction in 1969 was relatively minor. Preliminary work on ground clearing at the Valdez terminal site was authorized by the Forest Service (the site lay in the Chugach National Forest). A short segment of the haul road connecting the south bank of the Yukon River to the end of the state highway system was authorized by the Interior Department.

The environmentalists adopted a number of tactics designed to prevent or slow down approval. Public relations tactics depended primarily on the

use of the media to acquaint Americans with the potential dangers of the project and to mobilize citizen pressure on Congress. Lobbying and direct testimony at each of the several congressional hearings was used to try to influence members of Congress directly. However, the most effective delaying tactic for the environmentalists turned out to be the court suit.

In January 1970, the Secretary of the Interior issued a Public Land Order establishing a transportation corridor, which would presumably have been followed by the appropriate permits for the pipeline itself. Opponents and critics of the pipeline turned to the courts. In March and April 1970, several suits were filed in the federal courts by both indigenous Alaskan groups and environmental organizations. The three basic sources of legal grounds for challenging the TAPS plan were:

1. The 1920 Mineral Leasing Act, which specified that a pipeline right-of-way should consist of the ground necessary for the width of the pipe plus 25 feet (8 meters) on either side. TAPS required a 100-foot (30-meter) right-of-way. The Mineral Leasing Act provided a legal basis for those opposed to the pipeline to delay it through court challenge. (In reality, the extra width presented no problem in terms of land availability, but it did provide the technical grounds for challenge.)
2. The Alaska land freeze brought about by the claims of indigenous residents. Resolution of those claims was required before a permit would be granted.
3. NEPA, which became the primary basis for legal challenge to TAPS plans.

In April 1970, three environmentalist groups (the Wilderness Society, the Environmental Defense Fund, and the Friends of the Earth) petitioned in court to bar issuance of permits under provisions of NEPA and the Mineral Leasing Act. Initial arguments based on NEPA contended that an EIS had not been prepared, as required by law, and that opportunities for public input had not been sufficient. When the courts finally refused to accept the environmentalists' contention of noncompliance with NEPA, the environmentalists returned to the right-of-way width issue as a legal basis of argument. On this issue the courts upheld their position, and the Interior Department was not allowed to issue the requisite permits. The Trans-Alaska Pipeline Authorization Act finally removed this barrier.

Indigenous Alaskan groups at first had thought that the TAPS project would offer them jobs, and several villages had signed waivers allowing

TAPS to cross the lands they were in the process of claiming in return for a promise of jobs on the project. However, when TAPS announced the first awards of contracts, indigenous businesses failed to get even a single contract and disillusionment set in. The villages withdrew the waivers and instituted a law suit. For a period of time the environmentalists and indigenous residents were allies, but as the oil company lobbyists interceded on behalf of interests in Congress, the alliance weakened. The passage of ANCSA destroyed the basis for large-scale indigenous opposition, while the provision of the act which created profit-seeking indigenous regional corporations also created a powerful incentive for indigenous residents to support economic growth and development in Alaska. Over a period of time, local residents would assume ownership of 44 million acres of land, some of which would have oil and gas potential. A pipeline would also be required to transport their oil. ANCSA also removed the original basis for the land freeze in Alaska.

During this period of opposition and debate, TAPS (which was reorganized and incorporated as the Alyeska Pipeline Service Company [Alyeska] in 1970) had relatively little control of events and was forced into essentially a position of reaction. *The original design plan had to be modified from one in which about 95 percent of the pipeline would be buried to one in which only about half would be buried.* Increasingly tighter stipulations proposed by the Interior Department further restricted Alyeska's freedom of choice in design and construction practices.

The State of Alaska suggested its own solutions: first, by proposing to build the haul road itself, and second, by suggesting that the state take over the pipeline's financing in an effort to increase the state's own assets. Both concepts were rejected by Alyeska, which was now estimating project costs at U.S. \$3 billion or more.

Major discussion about basic alternatives quickly began to focus on the two fundamental possibilities: the TAPS proposal and the trans-Canada alternative. Although a complete tanker system and a railroad system continued to be advocated by some, these systems never generated sufficient support to become serious contenders. Transportation of oil directly by tanker from the North Slope presented the massive problems previously outlined. Although a basic decision to build a pipeline had already been reached by the oil companies, the experimental voyages of the specially constructed *S.S. Manhattan* are illustrative of the problems with a tanker system. The *Manhattan* was a reinforced tanker which Humble leased for a test voyage from the east coast to Prudhoe Bay through the Northwest Passage. Accompanied by an icebreaker, the *Manhattan* experienced much difficulty with the ice. Despite its special construction, it had to be freed from the ice on several occasions, and on the voyage back from Prudhoe, a projection of ice ripped a long gash in the hull.

Transportation by railroad would involve immense construction expense, with many of the environmental problems associated with a pipeline, as well as significant operating costs. The oil companies had briefly considered a railroad but quickly rejected this concept. (An Interstate Commerce Commission report in 1969 showed that the average railroad charge per ton-mile was five times as high as that for pipelines.) A variety of studies examined the cost and environmental characteristics of most major alternatives. Because each had to make economic and other assumptions in the analysis, the results were often contradictory and open to criticism.

5.4.2 ENVIRONMENTAL CONCERNS

The oil companies were surprised that permits were not granted rapidly. After all, the economic benefits to the nation and to Alaska of developing the North Slope oil were obvious. While there would be some environmental damage as a result of construction, the oil companies were prepared to take steps they considered reasonable to minimize it. Besides, the damage would be limited to a very tiny proportion (about 0.01 percent) of Alaska. Hardly anyone lived there. In many of the foreign countries where oil companies operated, the authority for making this kind of decision would be clear and a rapid response could be expected. Even in the U.S., such decisions in the past had been made in a relatively straightforward manner.

TAPS, however, had underestimated the complexity of the situation. Environmentalists and many others were not ready to accept assurances by TAP that good pipeline design would automatically mean minimum environmental damage or to agree that all questions surrounding the TAPS project should be project specific. The TAPS proposal would be attacked as bad design, as environmentally undesirable, and as socially disruptive. The resulting debate would take four years.³

Opposition from the environmental movement became especially strong when those who placed a high value on environmental protection and preservation became aware of the proposed pipeline and its basic design.

In the view of environmentalists, major damage to the environment (both an esthetic heritage and the basis for subsistence economy for rural people) could occur through at least four distinct scenarios. First, poor construction practices and carelessness could pollute and scar the environment along the pipeline corridor. Because of Alaska's short growing season and the delicate character of the tundra in permafrost areas, recovery from local environmental damage would be a slow process at best. Stream siltation during construction and any oil spills that might occur could destroy the spawning grounds of anadromous fish. Second, since the proposed design called for burying the hot oil line in most areas where it crossed permafrost, the line

would then be inadequately supported and subject to buckling or rupture. Third, the route of the line crossed areas of severe earthquake activity, and the terminus would be located in an area which had experienced a massive earthquake (8.5 on the Richter scale) in 1964. Thus, a severe earthquake which could rupture the line and the storage tanks could cause a massive oil spill. Finally, the oil would be transported from the terminal at Valdez to the U.S. west coast in large supertankers. En route the tankers would have to pass through several narrow channels where the possibility of grounding or collision, again in the view of the environmentalists, would be great.

To critics, it appeared that the TAPS concept had been chosen prematurely, without adequate consideration of alternatives, and that no permit should be granted until all alternatives had been fully investigated. The answers to the North Slope Task Force seemed to confirm that the design was based on partial data and that the design was itself incomplete. TAPS executives, however, pointed out that pipelines (unlike most projects) could be designed and built sequentially. Despite criticism from environmentalists, economists, and others concerned with both oil and impact, the oil companies (which could finance such a massive project) held unflinchingly to their first choice.

5.4.3 APPROVAL

Over a period of time, the courts had considered the arguments of those opposing the pipeline and the counter arguments of those favoring it. On August 15, 1972, District Court Judge George L. Hart ruled that the legal requirements of NEPA had been met and that the Interior Department could deal with the right-of-way width problem by issuing special land use permits. However, an appeals court reversed that ruling because of the Interior Department's lack of authority to issue special permits. The U.S. Supreme Court then refused to review the appeals court decision. Thus, in 1973, the issue was back in Congress, which now alone had the power, in effect, to authorize the pipeline through special legislation.

Indications of an energy crisis were by now apparent to many in Congress. A number of bills were introduced by members, and the hearings process started once again. As an acceptable bill began to evolve, events in the Mideast dramatized the seriousness of the energy problem for the U.S.. The Trans-Alaska Pipeline Authorization Act of 1973 passed overwhelmingly in both houses of Congress. The way was clear for the issuance of the required permits, but the estimated cost of the pipeline had now climbed past \$4 billion. In addition, the act provided for formal public agency involvement which would influence project construction, as noted in the Supervision and Control Task.⁴

5.4.4 ACTIVATION

In planning for implementation of the TAPS project, attention had to focus on the Alaskan construction cycle. The traditional construction cycle in Alaska begins in winter, when temperatures drop to -75°F (-59°C). In this viciously cold portion of the year, the Arctic tundra is frozen and its delicate surface is less likely to be damaged by the movement of the equipment. During the dead of winter, heavy equipment and materials are moved to construction sites across temporary snow roads and ice bridges made by compacting several layers of snow and ice on the top of frozen ground, river, and lake surfaces. The next step in the construction cycle begins in early spring. Warm weather by late March or early April allows workers to achieve normal productivity levels. Once begun in spring, work often continues around the clock either until the project is completed or the weather cools in the fall. Most construction not completed by late September or early October is abandoned until the following spring; winter construction normally is too costly. Significantly, projects that are even one month off schedule in October are potentially months behind. Work not finished by October must wait up to seven months, until the following April, to be completed.

Decision making on project organization, bidding and contracting, information and control systems, and resource procurement and allocation was handled by the Alyeska owner companies. The eight firms that controlled the pipeline venture comprised the owners' committee. The owners retained direct responsibility for setting overall project policy, acquiring capital, and sharing profits or losses. Agreement on project policy by the owners was a common prerequisite for major construction decisions and actions. For example, agreement between the owners was necessary before major contractual arrangements could be formalized by Alyeska, such as which construction management contractor (CMC) to hire. Contractual arrangements, however, were just one of hundreds of necessary policy making decisions, since almost every aspect of construction was touched by the owners. In short, since each owner company was a massively large employer in its own right (ARCO, for example, had about 55,000 employees), it was able to use some of its own employees at every stage of the project to gain valuable information for decision making.

One of the more efficient information-gathering structures for owner decision making was the ad hoc subcommittee system, by which technical and expert advice flowed up the chain of command from the subcommittees and Alyeska. Then, once policy was made, the owners controlled the implementation process down the chain of command by allowing the ad hoc subcommittees to work with all levels of the organization.

Throughout the 1969–1973 debates, Alyeska was tireless in its promises to provide blue-ribbon environmental protection. At an oil spill conference in the nation’s capital in 1973,⁵ for example, Alyeska presented a paper that it reprinted for distribution. In that paper, the pipeline company described its ambitious environmental plans. Among the claims of that brochure that were never implemented:

- Tankers calling at Valdez would be no larger than 150,000 dead-weight tons;
- The pipeline would be welded and inspected to national welding standards;
- The leak detection system would detect all but very small leaks;
- The entire pipeline could be shut down in five minutes;
- The oil spill contingency plan would be completed and tested one year before start-up.

With impending war in the Middle East threatening the U.S. oil supply, in July 1973 Congress ended the protracted environmental debate and authorized the construction of TAPS. The agreements contained stipulations that spelled out, in virtually identical language, stringent requirements addressing a wide variety of environmental concerns. These included contingency plans for oil spill response, a quality control program, and a requirement that every mainline field weld be X-rayed to ensure its adequacy. The legal arrangements also guaranteed that the construction of TAPS would be overseen by a large monitoring bureaucracy; they did not guarantee the effectiveness of that effort.

To build the pipeline in 1969 the owners formed the Trans-Alaska Pipeline System (TAPS) with personnel borrowed from the parent companies. To bring the project together, they formed a committee system with an eight-person Owners Management Committee and a three-person Project Management Committee. The duplicative committee structure resulted in what a spokesman for one owner called “organized chaos”.⁴

In an effort to create a more efficient arrangement, the owners incorporated Alyeska in August 1970.⁴ The name “TAPS” stayed with the pipeline; so did the organizational problems. After all, the new corporation was only a shell with no history or experience. Much of its staff was on loan from the parent companies. To spend money to plan and build the pipeline, Alyeska still had to obtain approvals from the various owner committees.

Alyeska wanted to retain Bechtel Corporation as a supervisory planning contractor to plan the pipeline and roads portion, which was then thought to be the greater challenge. The owners refused. Instead, the owners mandated

a limited planning assistance contract with Arctic Constructors, a construction consortium headed by Texas-based Brown and Root. In doing so, the owners ignored Alyeska's concern that Arctic Constructors lacked the resources for even the limited job the owners had authorized.

After Congress approved the project in 1973, the owners authorized Alyeska to enter into negotiations with Bechtel to develop plans for construction that included transportation, camps, contracting, and quality control. Alyeska did secure approval to retain Fluor Engineers and Constructors (Fluor) for terminal and pump station construction planning and management — then thought by Alyeska to be a more or less routine undertaking. Review of management communications confirms that the engineering and construction process Fluor supervised was chaotic. The extent of the problem became evident early in the project, as Fluor quickly discovered shortcomings in the engineering drawings and design data Alyeska provided. The West Tank Farm for oil storage had to be relocated and redesigned; piping and material specifications were inadequate. By May 1973 — five months after Fluor began work — cost of the preconstruction design and procurement phase of the contract was increased from \$7 million to \$17 million.

Throughout 1973 design work lagged behind schedule. Major components of this delay were the terminal's power plant and vapor recovery system (VRS). In mid-1973, design of these facilities was slated for completion by the middle of the next year; by November 1973, design completion was moved back to later in 1974. By June 1974, completion of terminal engineering design work was further delayed into 1976 — the year that terminal construction was supposed to be complete. Fluor required the extra time to complete terminal engineering because of "changes brought about by the Terminal Tank Farm redesign, reassessment of electrical work turned over by Alyeska which Fluor claimed was incomplete, and some omissions in Fluor's base estimate."

5.5 PHASE 3: OPERATION, CONTROL, AND HANDOVER

5.5.1 IMPLEMENTATION

5.5.1.1 Brief Overview

The builders of the Trans-Alaska pipeline tried to follow Alaska's traditional construction cycle. Snow roads and ice bridges were built following construction permit authorization in December 1973. Heavier equipment and materials were moved across the frozen arctic surface to construction camps between January and April 1974. Official construction commenced on April

29, 1974, in warmer weather. Workers and remaining materials were airlifted to construction zones after the snow and ice bridges had melted. The entire first portion of the construction plan — the haul road — was completed during the first construction season. Most of the other portions of the construction plan — the 800 miles (1287 kilometers) of pipe, the pump stations, and the marine terminal in Valdez — were completed during the 1975 and 1976 construction seasons. Some final construction was accomplished early in the 1977 season. Oil was introduced into the pipeline at Prudhoe Bay as scheduled on June 20, 1977.

The project's organization structure and manpower level tended to change with the flow of construction activity. In July 1974, the proportionate ownership of the pipeline changed; Sohio, ARCO, Exxon, and British Petroleum now owned 90 percent. During that same summer, the highest number of administrative and craft workers — approximately 3400 — were employed. Major portions of actual construction were completed during the 1975 and 1976 construction seasons. Employment levels reached 21,000 during the summers of 1975 and 1976, with approximately 26 million employee-hours totaled by craft workers in each construction season. In 1977, Alyeska began to demobilize itself as a construction company and shifted its organization structure to that of an operating company. The level of construction tapered off in 1977 to a total of less than 11,000 workers.

An example of the project's organization structure in 1975 is shown in [Figure 5.2](#). Responsibility and authority for all construction rested at the top of the management pyramid. This meant that the relatively few firms at the head of the organization, such as Alyeska, supervised all portions of construction simultaneously. In contrast, each of the many firms at the middle and bottom levels of the organization had only limited responsibility and authority by contract for a portion of the haul road, the pipeline, the marine terminal, or the pump stations.

5.5.1.2 Construction of Haul Road

Private management's coordinated effort to build the haul road is indicative of the massive scale of the entire project. Some 358 miles (576 kilometers) of highly compacted and graded gravel surface road were constructed in the arctic wilderness, along with 39 bridges, 1029 culverts, 11 airports, and 135 mineral acquisition sites. Over 7000 employees attended the one-day orientation necessary for authorization to pass north through the Yukon River checkpoint; 3596 employees (including cooks, drivers, and janitors) made up the on-site support force for the equally large construction crews (tradesmen and supervisors), all of whom were warned not to disturb any of the area's wildlife.⁴

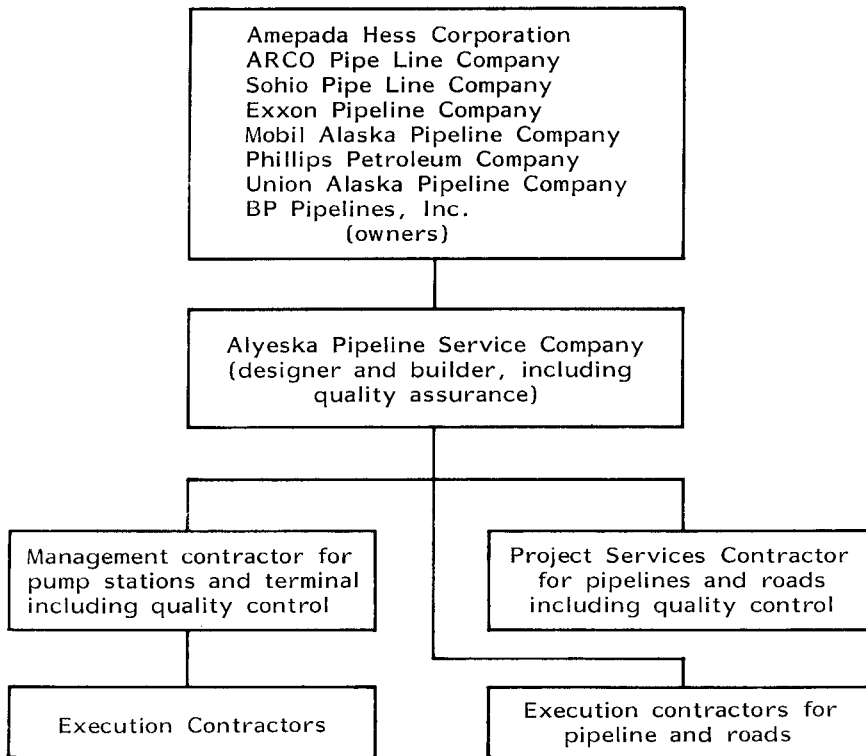


FIGURE 5.2 TAPS Project: revised organization structure (summer 1975). (From Trans-Alaska Oil Pipeline—Progress of Construction Through November 1975. Report to Congress by the U.S. Comptroller General, February 1976.)

Although Alyeska had exclusive use of the highway during pipeline construction, its ultimate ownership reverted to the State of Alaska. The haul road was begun at Livengood in May 1970 and was completed at Prudhoe Bay in September 1974. Because of complications and delays caused by competing interest groups (similar to those associated with all phases of construction), more than five years were required to design, gain approvals for, and complete a road that required only nine months of actual construction time. The road itself was divided into eight sections. Five construction contractors were assisted by 7 local contractors and regulated by at least 14 government agencies, including 8 federal agencies and 6 from the State of Alaska.

Within the first six-month period allowed by the traditional construction cycle, employees working on the haul road had to learn how to use the special arctic equipment, to understand the constantly changing land forms of Alaska (from arctic desert to the highest mountains in North America) and soil characteristics, and to construct the road across pristine wilderness.

Coordinating construction was complicated because Alyeska's corporate headquarters was maintained in Anchorage, but actual haul road construction headquarters were 355 miles (571 kilometers) to the north, in Fairbanks. In addition, no connecting roads or normal communication links existed. Coordinating haul road construction was further complicated by arctic weather and atmospheric conditions. Specifically, changing arctic weather patterns often delayed the delivery of airlifted workers, supplies, and equipment to construction points. Arctic atmospheric conditions are among the strangest in the world. Communication by voice radio is unreliable at best. In sum, the normal supervision and control methods for building the haul road, indeed all portions of the project upon which management relied, were thwarted by the size, geographic location, uniqueness, and complexity of the project.

5.5.1.3 Pipeline Construction

The scope of the Trans-Alaska pipeline project is massive by any standard. It is often described as the largest construction project undertaken by private industry in history. While such a claim is difficult to prove, it is probably fair to say that it is the largest construction project undertaken by contemporary private industry. The scope is vast for each of the four parts of the project's construction. In comparison, the work associated with the pipeline itself was probably greater than that of the other three parts of the project (haul road, pump stations, and marine terminal). Nearly 15,000 workers were assigned to pipe installation and related tasks during the summer peak in 1975 and 1976. The workers assigned to lay pipe worked on clearing the right-of-way, laying a gravel pad to protect the environment from damage by heavy equipment, or installing the pipe itself.

The first 1900 feet (579 meters) of pipeline was buried beneath the Tonsina River on March 27, 1975. Tractor-backhoes ditched the Tonsina to depths of 18 feet (5 meters) below the stream bed and up to 10 feet (3 meters) below the maximum scour depth of the river channel. Each 300-foot (90 meters) section of pipe was precoated with 9 inches (22.9 centimeters) of concrete to combat the buoyancy of the empty line. The cement coating, which weighed 80,000 pounds per 40 feet (12 meters) of pipe, anchored the pipe in its burial ditch. Tractors with side-mounted booms picked up the

sections of pipe in webbed slings, holding the pipe for welding of additional sections to each end until the 1900-foot (579 meters) span was completed. As more pipe installation continued along the right-of-way, the realities of the Alaskan terrain began to cause engineering and design modifications. Alyeska engineers had detailed the pipe-laying work on a mile-by-mile basis from Prudhoe Bay to Valdez before construction began, but these plans had to be constantly changed. When crews drilled holes for vertical support members (VSMs), for example, subsurface soil conditions often caused the pipeline to be moved from one side of the right-of-way to the other; or, more expensively for Alyeska, portions of the pipeline planned for burial had to be elevated to avoid harm to the permafrost. But despite design changes, actual pipe laying moved quickly.

Pipe-laying activities forged ahead of other portions of the project during 1975 because pipe burial and installation did not require the extensive site preparation common to terminal and pump station construction. By 1977, however, pipe laying had slowed; three sections of the line were part of the last construction completed on the entire project. First, glacial soils in the original burial route and avalanche danger at the 4790-foot (1460 meters) Atigun Pass in the Brooks Range led to several route and design changes. An 8-square foot (2 m²), 6000-foot long (1829 meters long) concrete box with the pipe inside in a 21-inch (53 centimeters) thickness of Styrofoam was built. This entire unit was then placed at a steep vertical angle along the side of the right-of-way crossing Atigun Pass.

At Keystone Canyon, Section 1, the pipeline had to be rerouted along the canyon's 4-mile (6 kilometers) lip because the highway prevented the laying of pipe on the canyon floor. At first, tracked vehicles such as bulldozers pulled materials and equipment up the canyon walls, but the rock faces proved too steep for drilling crews. Heavy equipment and materials were disassembled, flown to the top of the canyon, and reassembled above the rock face. Helicopters airlifted crews and materials to one of four canyon-top staging areas where, when work resumed, portions of the pipe were laid along a 60 percent grade. At the 2500-foot (762 meters) Thompson Pass, Section 1, crews were faced with several miles with 45° slopes. Since the pipeline route followed an almost vertical grade, heavy equipment was anchored to the slopes by cables; in fact, the pipe itself was winched up the side of the pass with a cable tramway system. Welders lashed to the pipe to keep their footing worked the entire 1976 construction season to complete the job. Not surprisingly, the last portion of pipe to be laid was at Thompson Pass.

The contractors (ECs) for the pipeline were Morrison-Knudsen (145.24 miles); Perini Arctic Assoc. (148.89 miles); H. C. Price Co. (151.84 miles); Assoc. Green (127.34 miles); and Arctic Constructors (222.17 miles).

5.5.1.4 Construction of the Marine Terminal and Pump Stations

Responsibility for the marine terminal in Valdez and the initial eight pump stations was contracted to the Fluor Corporation on December 21, 1972. Fluor completed most of the major planning and design work for its two portions of the project by July 1974, although some engineering changes occurred as late as the summer of 1977. Fluor's management activities are distinguished from those of the rest of the pipeline project by a number of important characteristics. First, since much of Fluor's work was performed indoors, crews worked all winter. Also, because the crews worked year round, workforce levels tended to remain relatively small. Fluor used 5000 to 6000 workers during the construction peak in the summers of 1975 and 1976. The construction crews at Pump Section 1, Prudhoe Bay, fluctuated between 270 and 430 workers between January and August 1976.

Fluor's management, however, did find its tasks to be more complicated than those on previous pipeline construction projects. Welding required extra ability because of the special chemistry of the low-temperature metallurgy. Unusual stress, snow loads, permafrost, earthquake safety requirements, and government monitoring stipulations combined to make the Alaska terminal facility and pump stations unique. Fluor supervised the terminal construction separately from the pump station construction.

5.5.2 SUPERVISION AND CONTROL

Alyeska Pipeline and Service Company was responsible for overall project management, with Bechtel, Incorporated, and the Fluor Corporation as CMCs. Since the Alyeska Project Management (Alyeska) had responsibility and authority for construction, it implemented the policies set by the owners. Specific tasks performed by Alyeska to meet its responsibilities depended upon the stage of construction — from planning and engineering to building. When during planning, for example, several companies were interested in becoming CMCs, Alyeska reviewed their initial proposals and recommended to the owners which firms should be awarded contracts.

Alyeska's engineering tasks included the design of the pipeline (originally planned for burial over 90 percent of its length). The engineering team revised this original design almost continuously throughout the project, so that at completion approximately 52 percent of the pipeline was buried. Alyeska's building task was to supervise the firms doing the actual construction. As project manager, Alyeska did not wish to supervise on-site construction; it intended to audit and ensure fulfillment of contractual obligations by the CMCs.

Among the other responsibilities delegated to Alyeska were preparation, revision, and control of the project budget. Constant revisions were necessary in order to maintain control of the budget because it escalated from U.S. \$900 million initially to U.S. \$4.5 billion in 1974, to U.S. \$6.5 billion in 1975, to U.S. \$7 billion in 1976, to U.S. \$8 billion in 1977, and growing. Estimates attribute approximately 50 percent of these budget revisions to inflationary pressure, 30 percent to environment requirements, and 20 percent to other items such as design changes or changes in engineering standards imposed by reviewing government agencies.

In addition to these more usual management duties, Alyeska provided a focal point for extensive government regulatory activity. Government agencies found it easier to go directly to Alyeska rather than to deal with each owner individually. Acting in this capacity, Alyeska satisfied environmental protection regulations by providing a steady stream of reports concerning the impact on the approximately 30,000 acres (12,141 hectares) of land disturbed by construction. Government agencies required Alyeska to make reports regarding erosion control, construction-related oil spillage, sewage treatment standards at the construction camps, fair employment commitments, and damage to wildlife, for example. Alyeska was also responsible for public relations, including hosting government officials inspecting pipeline progress.

The CMC duties were divided. Bechtel was responsible for construction of the haul road and pipeline, and Fluor for the pump stations and marine terminal. Each CMC was given decision-making latitude within the boundaries of its specific tasks. However, Alyeska and the owners expected the CMCs to develop transportation plans for equipment to the job site, to plan construction camps, to set up policies and procedures to be followed by the execution contractors (ECs), to establish an organization for on-site quality inspection, to determine a method for strengthening control over the ECs, and to set up a procurement organization to achieve cost savings by buying needed supplies and equipment in bulk.⁶

The relationship between the CMCs and other members of the organization differed. On the one hand, Fluor worked in conjunction with Alyeska to design the pump stations and marine terminal. Accordingly, Fluor was intimately familiar with the engineering aspects of its tasks. Since much of the engineering design directly supervised by Fluor was then built by its own subsidiary, the Fluor Construction Company, rather than another EC, the transfer from design to finished product was much simpler on the Fluor-supervised portion of the project. In addition, Fluor's supervisory communication links were relatively simple because each of its tasks was centrally located. On the other hand, Bechtel did not work in conjunction with Alyeska to design the pipeline and haul road. Alyeska's engineering of both left

Bechtel to manage the actual building through a multitude of ECs. Since it was responsible for building the pipeline and haul road according to Alyeska's specifications, Bechtel, unlike Fluor, began its duties without intimate familiarity with the engineering aspects of its tasks. Thus, at first, Bechtel could not supervise as closely the work being done by its ECs. Also, unlike Fluor, Bechtel's supervisory communication links were relatively complex because its two tasks were spread out over 800 miles (1287 kilometers) of Alaskan wilderness. Bechtel's ability to supervise and control its portions of the project, therefore, was somewhat reduced.

Alyeska's management role was modified greatly by top-level management decisions. In practice, Alyeska's role became that of mediator among the various management levels in the organization. As already suggested, the opinions of the owners, their ad hoc subcommittees, and Alyeska differed.

Alyeska's project management team, as well as most of its internal organization, consisted of employees on loan from the owner companies. These employees had the management philosophy and style associated with their own companies. Consequently, Alyeska's organization encompassed every management approach from democratic to authoritarian; no particular management philosophy prevailed. In addition, Alyeska's employees generally did not have a career-oriented commitment to the firm.

In summary, supervision and control left much to be desired because of lack of coordination and cooperation in a complex project plagued by inadequate planning and a duplicative four-tiered management structure established by the owner companies: (1) the owners' committee, (2) Alyeska, (3) Bechtel (pipeline and haul road) and Fluor (pump stations and terminal), and (4) ECs.⁷ The owners terminated Bechtel's employment in 1975, with Alyeska assuming responsibility as CMC.

Superimposed on this cumbersome and inefficient management structure was the public agency involvement at both federal and state levels. Public management was formally organized so that the federal authorizing officer, the state pipeline coordinator, and the Joint Fish and Wildlife Advisory Team did most of the monitoring. These three agents, along with several others, had the power to halt the project if construction activities violated the law.

5.5.3 COMPLETION AND HANDOVER

To Alyeska, perhaps the final measure of the success of the project was the call for "oil in" at Prudhoe Bay in 1977. Start-up of Alaska's oil pipeline presented unique technical problems. The oil was hot and the pipeline was cold. The pipeline heated while the air cooled until the two reached the same temperature. The temperature difference at the beginning was great; the oil reached the pipeline at a temperature as high as 160°F (71°C); the pipeline's

average temperature was 20°F (−7°C). The conventional method of starting a pipeline is to fill it with water in order to remove oxygen that could explode when mixed with hydrocarbons, place a separator called a “pig” in the line, and remove the water by moving crude oil through the line behind the separator. In Alaska, however, this method could not be used because the water would freeze. Rather than using water, the Alaska pipeline used nitrogen, which is an inert gas that cannot support combustion. The oil was put in the line and a ground party moved southward from Prudhoe Bay. The ground party inspected for oil leaks, checked clearances between shifting pipe and pipe supports, and looked to see that the vertical support members were able to accommodate the weight of the filled pipeline. For several weeks, crews continued to check and double-check for oil leaks and weight distortion.³

Oil spills along the pipeline are not desirable for anyone. Nonetheless, they are almost inevitable. The pipeline design included highly sensitive oil leak detection devices. Public management required workers to report all oil spills regardless of size. When oil leaked, Alyeska would advise the proper government regulatory agency. Apparently, four major oil spills occurred during construction.^{8,9} First, an estimated 60,000 gallons of fuel leaked from a buried pipeline at Galbraith Lake. This was not discovered immediately because the holding tanks feeding the line were filled on a routine schedule and no control existed over the amount of fuel being consumed. Second, an explosion at Isabel Pass caused havoc in a fuel yard. Barrels of fuel were crushed by falling rock, and workers spent two days cleaning the areas, as well as bringing in new soil to cover the spill. Third, a tanker truck overturned at Chandalar, spilling 8500 gallons of fuel. A fourth spill of about 70,000 gallons occurred at Prudhoe Bay in January 1976. Fuel tanks were mistakenly topped off when the temperature was −50°F (−46°C). When the temperature rose to 60°F (15.5°C) in 12 hours, a valve burst and oil spilled on the tundra. The cause of the spill appears to have been a lack of understanding about the special weather conditions of the far north. Because so many possibilities exist for oil spills unrelated to the actual movement of oil through the pipeline, Alyeska trained and equipped an oil spill cleanup crew, which was kept on immediate standby.

For the most part, the pipeline start-up process was relatively smooth, with only a few minor problems typical of those encountered in the early stages of any massive system. There was one major exception, however. At Pump Station 8, a relatively minor problem of cleaning a strainer was compounded by human error (which itself may have been made possible by an inadequate fail-safe feature in design). The result was an explosion and a fire which destroyed the station, killed one man, and injured several others. The damage was estimated at tens of millions of dollars, and without the

pressure of the pumps at Station 8, the pipeline had to be operated for months at a flow rate of 800,000 barrels per day — two thirds of the initial expected operating rate. The owner companies thus experienced a consequent loss of revenue.

Alyeska found itself with huge amounts of surplus construction equipment that had to be sold at the completion of the project. This sale, which took approximately two years to complete, was perhaps one of the largest surplus equipment sales ever recorded, save after major wars. Alyeska's list of over 20,000 items of used equipment had cost U.S. \$800 million to purchase and included 240 cranes, 119 backhoes, 719 bulldozers, pipe layers and loaders, 1340 generators, 1357 trucks, 3315 other vehicles, and 1637 welding machines, as well as 1500 gas-heated outhouses, originally priced at \$10,000 each. Aside from its size, this surplus sale is significant for the several hundred million dollars in revenue that it generated, which had to be deducted from the total construction costs.

The owner companies were guaranteed a reasonable rate of return on their investments based on the cost of building the pipeline. Similarly, the State of Alaska was to receive a royalty that could be affected by the cost of building the pipeline. Thus, both private and public management were concerned with the surplus-sale dollars. Private industry needed to dispose of the extra equipment. Public management needed to ensure that the surplus equipment brought a reasonable price because Alaska's royalties on Prudhoe Bay production would be reduced for years to come if the equipment was sold for too little.

The organization and construction work described previously evolved to build the Alaska pipeline. When construction of the project was completed during the summer of 1977, Alyeska was demobilized. In simplistic terms, Alyeska's construction company was dissolved and replaced by its operating company. All employment contracts were officially terminated, so that employees could return to their parent company or elect to stay in Alaska as part of Alyeska's operating company. The responsibility of the Alyeska construction company had been to build the Trans-Alaska pipeline. The responsibility of the Alyeska operating company is to operate and maintain the pipeline.

5.6 PHASE 4: EVALUATION AND REFINEMENT

5.6.1 EVALUATION OF PHASES 1 TO 3

Results and problems were analyzed in the framework of the integrated planning and quality management system (IPQMS).

5.6.1.1 IPQMS Phase 1

Phase 1 commenced in July 1968 with pipeline feasibility studies and continued through November 1973 with passage of the Trans-Alaska Pipeline Authorization Act. This formative or preconstruction phase was plagued by many legal challenges which delayed the start of construction. Unfortunately, the owners failed to take advantage of the lengthy delay to plan and design the pipeline, the pump stations, and the marine station in a systematic and thorough manner. The basic problem inherent in phase 1 and subsequent phases was one of mismanagement and indifference to project costs. The lack of adequate planning by the owners was exacerbated by their lack of understanding of the need for a *single* project management team to oversee the entire integrated project cycle.

Of particular concern in the feasibility studies was (1) inadequate geotechnical studies for later design and construction of the various structures, including the pipeline, and (2) lack of understanding of worker productivity, material procurement, and communication problems in the arctic environment. Indeed, there is no evidence that the feasibility studies seriously considered personnel needs to properly control and direct the project.

Inadequate design data were prepared for all components of TAPS. The consequent need to constantly revise designs during construction contributed greatly to the cost overruns. This was especially serious in the construction of the pipeline, pump stations, and marine terminal.

5.6.1.2 IPQMS Phase 2

One of the crucial problems of the TAPS project was that its organizational hierarchy and management structure were poorly conceived from the outset and were only marginally improved as the project progressed. Despite the ample time available to Alyeska and the owner companies prior to the start of construction, the available evidence shows inadequate planning and preparation for construction, as well as an ineffective management structure characterized by duplication and unclear lines of responsibility and authority.

Because of the confusing lines of management authority, the owners and Alyeska failed to establish (1) a project cost estimate plan and related control systems for implementation/expenditures and (2) viable contractor incentive plans for work in a difficult environment.

In addition, the management of TAPS failed to develop systems and procedures to ensure that construction equipment, material, and spare parts were purchased, delivered, and inventoried in a cost-effective manner. The result was an often chaotic situation. Execution contractors (ECs) desperately sought to requisition spare parts which were already located in their own

warehouses. Because of inadequate warehouse space, equipment and material were often stored outdoors and became lost after the first snowfall. By the time the spring thaw came, much material had either been ruined by the weather or stolen.

Equally serious was the failure to provide sufficient labor camp facilities, a cost-effective food catering service, and an adequate communications system. Again, as a result of late planning, TAPS construction began without adequate housing, catering control, or communication facilities in place. As a result, not only did expenditures for these vital support functions far exceed expectations, but the housing and communications problems delayed construction. They also caused numerous adverse ripple effects.

In sum, making policy decisions critical to the success of phase 2 was clearly influenced by self-interest on the part of the owners, compounded by lack of understanding of the project's needs. Indeed, this attitude prevailed in all of the phases.

5.6.1.3 IPQMS Phase 3

It is readily apparent from the previous discussions that there were serious disputes among the owners, Alyeska, and Bechtel concerning the appropriate scheduling of design and manpower, as well as the basic contracting strategy to be pursued with the pipeline's ECs. For example, Bechtel strongly recommended negotiating of contracts with ECs at the earliest possible time to allow their involvement in planning for the road and pipeline construction schedule for 1974. When this strategy was arbitrarily rejected, Bechtel correctly predicted that the resulting loss of construction and planning time would produce substantial cost overruns.

The Bechtel-Alyeska-owners dispute reflects a more profound problem. The duplicative management structure developed by the owners led not only to excessive administrative costs but also to paralysis of management's decision-making process. Confusion pervaded all levels of the project while the ECs, labor, Bechtel, Alyeska, and the owners attempted unsuccessfully to sort out their relationships and responsibilities. There is irony in Alyeska's and Bechtel's assessment of the same problems and their diametrically opposed solutions. For example, while Bechtel was demanding increased compensation for additional personnel to correct alleged Alyeska errors, Alyeska was criticizing Bechtel for utilizing unnecessary personnel in handling contractual duties.

Another serious and highly publicized implementation problem was that of workers frequently idle at the job site (including sleeping on buses and sunbathing along the right-of-way). Alyeska's own documents show that the principal responsibility for idleness rested with management's poor supervi-

sion and utilization of the work force. Most of the workers were willing to work but lacked “adequate direction and support” from a disorganized project management.

The impact of late and inadequate design work affected all ECs. The three major components of construction — the pipeline, marine terminal, and pump stations — were adversely impacted. The results of these deficiencies included (1) numerous and costly delays as men and equipment awaited overdue engineering decisions, (2) problems with efficient work rescheduling as contractors tried to build around those areas for which they lacked sufficient engineering, and (3) in some instances, work that had to be redone because of inadequate engineering studies and deficient designs.

5.6.2 REFINEMENT

The final task in the IPQMS is an evaluation of the three phases or the lessons learned from each completed project to provide a basis for refinement of the integrated project cycle. This task should provide useful insights for improving policy decisions, planning, design, and management of future projects. Geistauts and Hauck provide an interesting summary discussion of TAPS in the integrated project cycle framework.¹¹ Unfortunately, the oil companies and Alyeska did not perform this task.

A special study of construction costs was mandated by the Alaska Pipeline Commission. The resulting report concluded that over \$1.5 billion were lost to waste, fraud, and mismanagement.⁴

5.7 LESSONS LEARNED

Many of the TAPS construction problems could have been avoided if the owners and their project management group (the Alyeska Pipeline Service Company) had recognized the importance of teamwork among owners, planners, designers, constructors, and managers of projects during the preconstruction period (1968–1973). This basic need relates directly to the priorities of the construction industry in particular and to all projects in all sectors in general. Thus, this need becomes the basic lesson, which can be applied to all problem areas ranging from the TAPS project to the Spacecraft Challenger disaster on January 28, 1986.

The second lesson is the need for a detailed checklist of questions to be prepared by the owners and their representative, Alyeska, preparatory to commencing the feasibility studies. The checklist could be adapted from the

guidelines in [Appendix B](#). Equally important, the checklist would ensure proper attention to the feasibility studies, which should become the basis for preliminary designs, technical and environmental alternatives, and the subsequent tasks in the IPQMS.

The third lesson is the overdue need for a data base for planning, designing, and constructing a variety of public works and private sector projects in different environments. For example, a data base containing case histories of projects such as the Distant Early Warning (DEW Line) System would have been invaluable for the owners and Alyeska in planning TAPS. Indeed, the development of a data base for public works projects that would include case histories of a representative cross section of projects, both successes and failures, would provide valuable lessons and insights for the planning and management of future projects in the dual interest of safety and cost effectiveness.

A fourth lesson is the need for detailed feasibility studies, which serve a multitude of purposes ranging from preliminary design refinement (for cost estimates and manpower/equipment needs) to development of necessary baseline data for ongoing evaluation of subsequent tasks and environmental impact (both short- and long-term). It is clear that such detailed information would have avoided the majority of design and construction problems encountered with TAPS.

Related to the first four lessons are the lessons learned regarding the need for project responsibility and accountability, which cut across proper planning and implementation of communications systems, material and equipment procurement systems, construction control systems (including management of labor/worker productivity), cost control systems, and so on.

In sum, the lessons learned from the TAPS project are profound and have many implications for both educators and practitioners — for educators because of the overdue need to include public policy, project planning, and project evaluation in engineering curricula, and for practitioners (consulting firms, for example) who must interact with educators in developing the badly needed data bases discussed earlier. The TAPS experience confirms repeatedly the many problems that can occur when there is no teamwork and no accountability. It further emphasizes the importance of IPQMS case histories for both educators and practitioners. It also confirms the inseparable process of going from planning to design and through completion.

Unfortunately, the oil companies and Alyeska did not learn from their mistakes in the planning, design, and construction of the pipeline system.¹² This becomes apparent in the operation of the system ([Chapter 6](#)).

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